American POTATO JOURNAL

Volume 30 *October 1953* *Number 10*

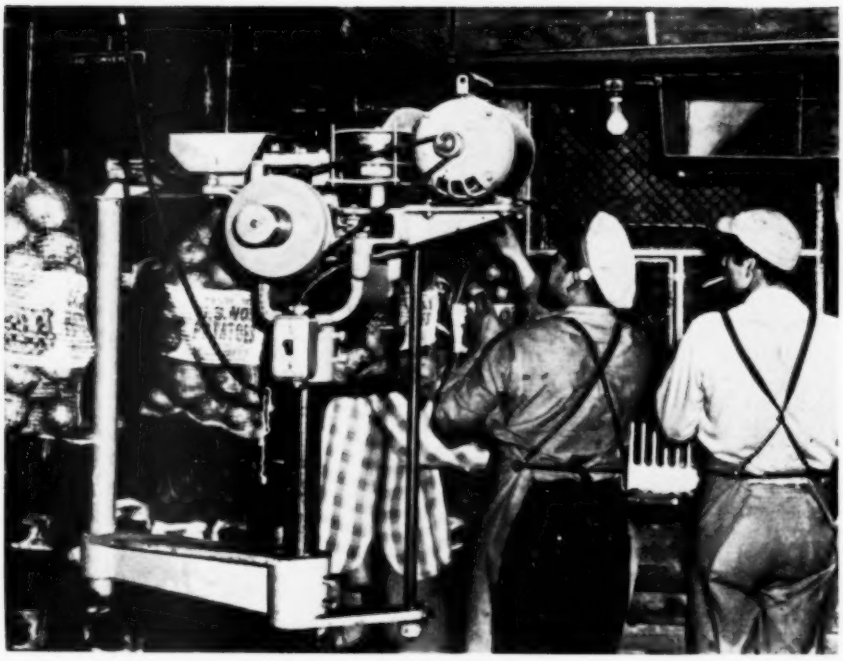
CONTENTS

The Relation of Weekly Mean Temperatures and Cumulative Rainfall to Late Blight Epiphytotics in Wisconsin—*J. R. Wallin, E. K. Wade and H. M. Darling* 231

The Effect of Depth of Planting on Germination, Level of Tuber Formation and Yield of the Potato Crop—*M. A. Moursi* 242

The Reduction of Injuries to Potato Tubers through the Use of Padding Materials—*R. B. Hopkins* 247

Official Organ of
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, NEW JERSEY



Operator at right check - weighing bags from the filling machine on EXACT WEIGHT potato scales — Denver Potato Co., Denver, Colo.

Packaging Potatoes at a Profit . . .

Potato profits just melt away if you have overweight bags . . . more potatoes than the net weight on the bag calls for. One or two more potatoes per bag creates a serious handicap to profitable operation and especially is this true in large scale business, ton after ton. The actual facts are you just bag much of your profit right with the potatoes. Your best insurance against this is sound checkweighing on specially designed EXACT WEIGHT Scales for potato packaging. Such equipment assures accurate weight bags and your packaging problems vanish. Write for details for your operation.

"Sales and Service from Coast to Coast"

EXACT WEIGHT SCALES

BETTER QUALITY CONTROL
BETTER COST CONTROL

THE EXACT WEIGHT SCALE COMPANY

921 W. Fifth Ave., Columbus 8, Ohio
2920 Bloor St., W • Toronto 18, Can.

Stop Potato Blights at Lower Spray Cost

Use Du Pont PARZATE®

Fungicide

Now you can stop both early and late blight and protect your crop all season long . . . with Du Pont "Parzate." It does the job better and at low cost, without burning or stunting the plants. "Parzate" will stand up under the worst blight conditions.

You get all these advantages with "Parzate"

- Thorough control of early and late blight.
- No stunting of plants. Vines reach maximum growth.
- Control disease with this one product all season.
- Avoid rot damage with complete blight control.
- Roguing for virus is easier. Doesn't mask foliage.
- You get more No. 1 potatoes at lower spray cost.

Two Handy Formulations

"Parzate" Liquid *(Nabam)*	"Parzate" Dry *(Zineb)*

DU PONT

BETTER THINGS FOR BETTER LIVING THROUGH CHEMISTRY

Try this new fungicide . . .

DU PONT MANZATE®

New "Manzate" fungicide is especially effective where early blight and late blight attack your potatoes at the same time. It is the latest in the Du Pont family of dithiocarbamate fungicides which includes "Parzate." Try "Manzate" this season . . . it, too, is easy on the crop but tough on disease.

See your dealer for "Parzate," "Manzate" and other proven Du Pont pest control products. Ask him also for informative booklets — Du Pont, Grasselli Chemicals Dept., Wilmington, Del.

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

EXECUTIVE COMMITTEE

WM. H. MARTIN, *Editor*
E. S. CLARK, J. C. CAMPBELL, *Associate Editors*
Rutgers University, New Brunswick, N. J.

J. W. SCANNELL, *President* ..... Department of Agriculture, Ottawa, Canada
ARTHUR HAWKINS, *Vice President* ..... University of Connecticut, Storrs, Conn.
R. W. HOUGAS, *Secretary* ..... University of Wisconsin, Madison, Wis.
JOHN C. CAMPBELL, *Treasurer* ..... Rutgers University, New Brunswick, N. J.
J. H. MUNCIE, *Past President* ..... Michigan State College, East Lansing, Mich.
CECIL FRUTCHEY, *Director* ..... Colorado A & M College, Ft. Collins, Colo.
N. M. PARKS, *Director* ..... Department of Agriculture, Ottawa, Canada
PAUL EASTMAN, *Director* ..... Department of Agriculture, Augusta, Maine

Price $4.00 per year in North America
$5.00 in other countries after January 1, 1954

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

SUSTAINING MEMBERS

H. H. ROBERTSON CO. ..... Pittsburgh, Pennsylvania
THE DOW CHEMICAL CO. ..... Midland, Michigan
STARKS FARMS INC. ..... Route 3, Rhinelander, Wisconsin
BACON BROTHERS ..... 1425 So. Racine Ave., Chicago 8, Illinois
L. L. OLDS SEED CO. ..... Madison, Wisconsin
FRANK L. CLARK, Founder — Clark Seed Farms ..... Richford, New York
RED DOT FOODS, INC. ..... Madison, Wisconsin
INTERNATIONAL HARVESTER CO. ..... Chicago, Illinois
ROHM & HAAS COMPANY ..... Philadelphia, Pennsylvania
CALUMET DIVISION, CALUMET & HECLA, INC. ..... 1 Calumet Ave., Calumet, Michigan
WISE POTATO CHIP CO. ..... Berwick, Pennsylvania
JOHN BEAN DIVISION, FOOD MACHINERY CORP. ..... Lansing 4, Michigan
S. KENNEDY & SONS, Growers and Shippers of Potatoes and Onions ..Clear Lake, Iowa
MATHIESON CHEMICAL CORP. ..... Mathieson Bldg., Baltimore, 3, Maryland
AMERICAN AGRICULTURAL CHEMICAL CO. ..... Carteret, New Jersey

We welcome the above firms as sustaining members and express to them our appreciation for their interest and financial support.

THE RELATION OF WEEKLY MEAN TEMPERATURES AND CUMULATIVE RAINFALL TO LATE BLIGHT EPIPHYTOTICS IN WISCONSIN[1]

J. R. WALLIN[2] E. K. WADE[3] and H. M. DARLING[4]

Weather-late blight studies on the eastern seaboard reveal that weekly mean temperature and cumulative rainfall were efficacious in forecasting late blight occurrence (3). The success of the eastern blight forecast method prompted a study of its use in Iowa (15), but it failed to differentiate between the severe, trace, and no-blight years. Recently (9), a weather-blight study in Connecticut corroborated the findings obtained earlier in the east. "The more rain, the more blight" was stated in the Connecticut publication.

The success cited in this latest publication suggested that the "cumulative rainfall" method deserves further attention. Therefore, it was applied to the Indiana late blight data but was again found to be ineffective. in separating blight from no-blight years (14).

Further attempts to employ weekly mean temperature and cumulative rainfall as a basis for blight forecasting seemed unwarranted in the North Central states except for the fact that the method had yet to be applied under the weather conditions characteristic of a northern state of the region.

The Wisconsin weather-blight data were selected for analysis because of the states excellent blight records and its cool, humid summer weather. The results and interpretations are presented herein.

THE METHOD

The 'cumulative rainfall' method of forecasting late blight was advanced and described in detail by Cook (3). However, as a reference, the method will be outlined briefly here. Underlying the method are two basic assumptions; 1 - that there is a critical period of blight initiation and 2 - that late blight development is the manifestation of temperature and cumulative amount of rainfall.

According to the published method (3), the "critical" period is found by analyses of the weather and blight histories of a given area.

[1]Accepted for publication June 17, 1953.
Report of an investigation conducted under the Agricultural Marketing Act (RMA Title II) in cooperation with the Wisconsin Agricultural Experiment Station. The authors wish to acknowledge the aid of Edward D. Jones and Leonard A. Sorenson in taking the hygrothermograph records at Antigo, Wis.

[2]Pathologist, United States Department of Agriculture, Bureau of Plant Industry, State Agricultural Experiment Station, Mycology and Disease Survey, Iowa Agricultural Experiment Station, Ames, Iowa.
[3]Assistant Professor, Plant Pathology, Wisconsin Agricultural Experiment Station, Madison, Wis.
[4]Professor Plant Pathology, Wisconsin Agricultural Experiment Station, Madison, Wis.

These analyses yield the month of blight incidence and the date in that month that the cumulative rainfall lines of the blight and no-blight years diverge. Apparently, then, the 'critical' period is in the month of first blight incidence and during the four-week period beginning seven days preceding the date of divergence of the cumulative rainfall lines.

During the "critical" period if blight is to develop in a given area, concurrent weekly temperatures and rainfall must remain within certain critical limits for the two consecutive weeks. The weekly mean temperatures must be equal to or less than 75° F. whereas the cumulative rainfall amount must equal or surpass a "critical" rainfall line. The line is established midway between weekly mean cumulative rainfall amounts of the blight and no-blight years. In forecasting from the critical limits cited above, blight would be forecast if the temperature and rainfall were favorable for two consecutive weeks during the "critical" period.

History of Potato Late Blight in Wisconsin 1915-1951

The earliest record of potato late blight in Wisconsin was 1915, at which time the disease was epiphytotic. The annual severity of this disease since 1915 is shown in the following table.

Table 1.—*The annual severity of late blight in Wisconsin. 1915-1951.*

Severe	Moderate	Slight	No
1915	1927	1916	1917
1924	1928	1918	1930
1926	1929	1919	1932
1938	1939	1920	1933
1941	1940	1921	1934
1944	1942	1922	1935
1950	1943	1923	1936
1951	1945	1925	1937
	1946	1931	
	1948	1947	
	1949		

In other words, late blight has occurred in Wisconsin every year for the past 15 years. Obviously, the blight years outnumber the no-blight years. Late blight has been moderate to severe during 11 of the past 12 years.

Rainfall and Temperature Data from Six Weather Stations in Wisconsin. 1915-1951

The rainfall and temperature data from Antigo, Brodhead, Milwaukee, New London, Rhinelander and Wausau, Wisconsin were compiled from the U. S. Weather Bureau Climatological Data. The six stations were chosen for their proximity to the commercial potato production centers. The weekly temperatures and rainfall from all stations were averaged for the period from June 1 to September 13.

Temperatures were averaged and rainfall accumulated from June 1 because that date preceded by seven days the date of divergence between the weekly cumulative rainfall averages of the blight and no-blight years. This conforms to the method described previously herein. Furthermore, assuming that in the field the blight fungus emerges in the potato shoot

developing from the seed piece, about four weeks are essential for the blight symptoms to become obvious. Hence, the weather conditions obtained after June 1 influence the degree of blight development during the season.

Comparisons of the Weekly Mean Temperatures and Cumulative Rainfall for all Blight Groups since 1915.

Temperature: The weekly mean temperatures for the severe, moderate,, slight, and no blight years were below the 75° F. "critical" line as shown in figure 1. During July the weekly mean temperatures of the no blight

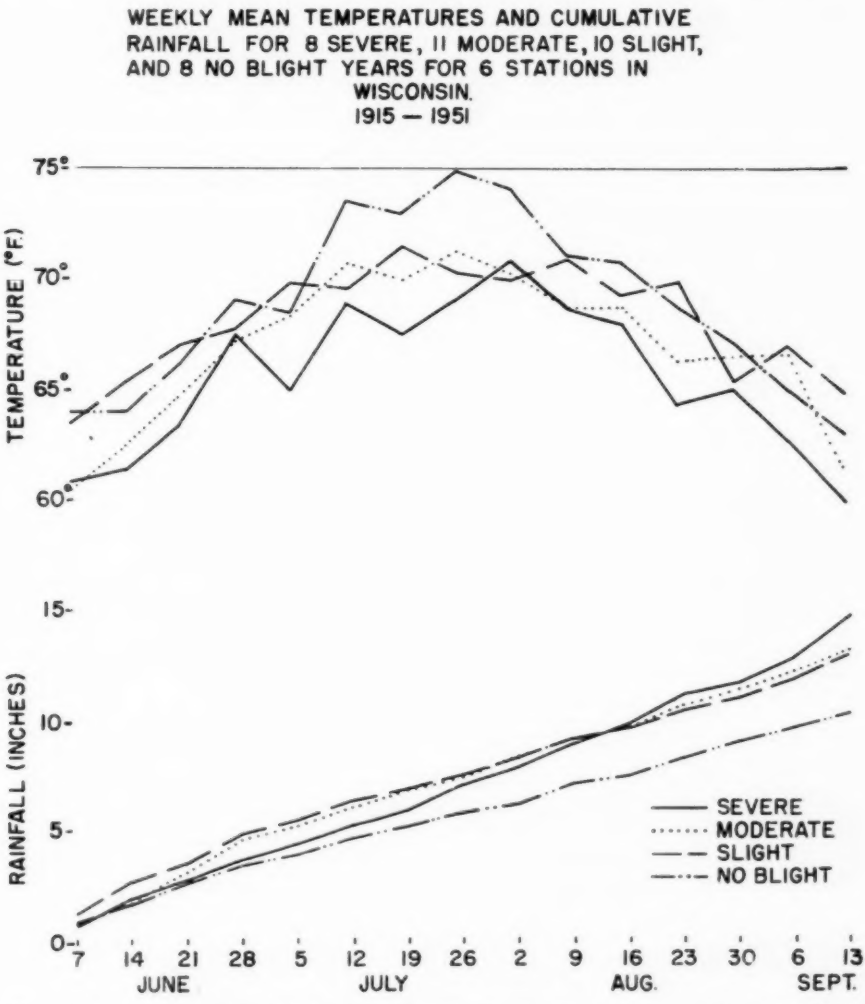


Figure 1.—A comparison of the weekly mean temperatures and cumulative rainfall for the severe-, moderate-, slight- and no-blight years.

years was found to be slightly higher than those of the other year groups. The temperatures differences between the severe, moderate and slight blight year group means were inconsequential.

Rainfall: Comparison of the weekly mean cumulative rainfall for the four blight year groups indicated that there were no great differences between them as you will also note in figure 1. After the eighth week there was only a 1.29 inch difference in rainfall between the severe and no blight groups. The relatively small difference between the severe, moderate and slight blight year means was most striking.

Critical Rainfall Line: Straight lines were fitted to the cumulative rainfall data for the individual years by the method of the least squares. The cumulative rainfall line slopes computed for the individual years were grouped on the basis of blight severity (Table 2). The variance analysis of the slope values of the four groups (Table 2) revealed no significant differences between the means of slopes for the four groups. This indicated, of course, that the differences between the blight and no blight group slopes were due to chance.

Although there were no significant differences between the blight and no blight groups, a "critical" line was established as the slope midway between the rainfall slope means of the severe-and no-blight year groups. The value of the resulting line slope was .81.

TABLE 2.—*Slopes of 37 least square lines through cumulative rainfall points for the fifteen week period beginning June 1 at six stations in Wisconsin. 1915-1951.*

	Blight Class							
	Year	Severe	Year	Moderate	Year	Slight	Year	No. Blight
1	1915	0.79	1927	0.81	1916	1.01	1917	0.93
2	1924	1.02	1928	1.04	1918	0.96	1930	0.78
3	1926	0.96	1929	0.93	1919	1.05	1932	0.42
4	1938	1.13	1939	0.82	1920	0.83	1933	0.67
5	1941	0.73	1940	1.22	1921	0.66	1934	0.87
6	1944	0.84	1942	0.90	1922	0.92	1935	0.94
7	1950	0.86	1943	0.98	1923	0.90	1936	0.51
8	1951	0.97	1945	0.80	1925	1.06	1937	0.51
9			1946	0.90	1931	0.86		
10			1948	0.63	1947	0.78		
11			1949	0.94				
Sx		7.30		9.97		9.03		5.63
x		0.91		0.91		0.90		0.70
Sx^2		32.70		58.46		48.54		24.07
K		8		11.00		10.00		8.00

Variance Analysis of Slopes of Four Blight Year Classes.

Source Variation	DF	SS	MS
Between Classes	3	.20	.066
Within Classes	33	.85	.026
Total	36		

$F = .066/.026 = 2.53$

Comparisons of the line slopes for the various blight year groups revealed that 75 per cent of the severe-, 82 per cent of the moderate-, 80 per cent of the slight- and 38 per cent of the no-blight year slopes were equal to or above the "critical slope.

However, the blight prediction method under consideration involves the use of concurrent rainfall and temperature data in interpreting blight occurrence.

The Relationship of Weekly Mean Temperature and Cumulative Rainfall to the Severity of Late Blight

In order to test the validity of the assumption that within favorable temperature limits "the more the rain the more the blight", "hindcasts" of blight for the individual years were developed from the weekly mean temperature and cumulative rainfall data. In accordance with the method successfully employed in the east, blight forecasts would have been issued it for two consecutive weeks of the 15-week period the mean temperature was 75°F. or less and the cumulative rainfall equal to or above the "critical" line previously described. Such "past" or hypothetical forecasts were developed from figure 2 in which the conforming temperatures and humidities are listed. The following summary of hypothetical predictions since 1915, as shown in table 3, is based upon any two consecutive weeks favorable for blight during June, July or June and July.

Table 3.—*Summary of hypothetical blight predictions since 1915.*

Blight Occurrence	Blight Forecast If Two Consecutive Weeks Favorable in					
	June		July		June and July	
	Yes	No	Yes	No	Yes	No
Yes	23	6	22	7	26	3
No	3	5	3	5	4	4

In the 'hindcasts' developed from two consecutive favorable weeks in June, blight was forecast 79 per cent of the time that it occurred. However, 21 per cent of the time that it occurred, blight would not have been predicted. Of these particular years, blight was slight in two, moderate in two and severe in two. Probably, if blight occurred in moderate or severe proportions and control measures were not recommended, a grower's faith in the forecasting method would be shaken. His faith would be proportional to the number of moderate or severe blight outbreaks that took his crop as a result of inaccurate prognostication.

Blight occurred in 75 per cent of the years that it was forecast from any two consecutive weeks favorable in July. Conversely, during 25 per cent of the years blight was forecast but did not occur. Of the inaccurate 25 per cent, blight was severe during two, moderate during one and slight during four years. Again these inaccuracies would destroy the effectiveness of the forecast method employed.

If any two consecutive weeks in June and July were considered to be favorable for blight initiation, ninety per cent of the positive blight forecasts developed from any two favorable consecutive weeks in June and July were accurate. Only ten per cent of the positive blight forecasts were incorrect. However, blight was severe, moderate and slight, respec-

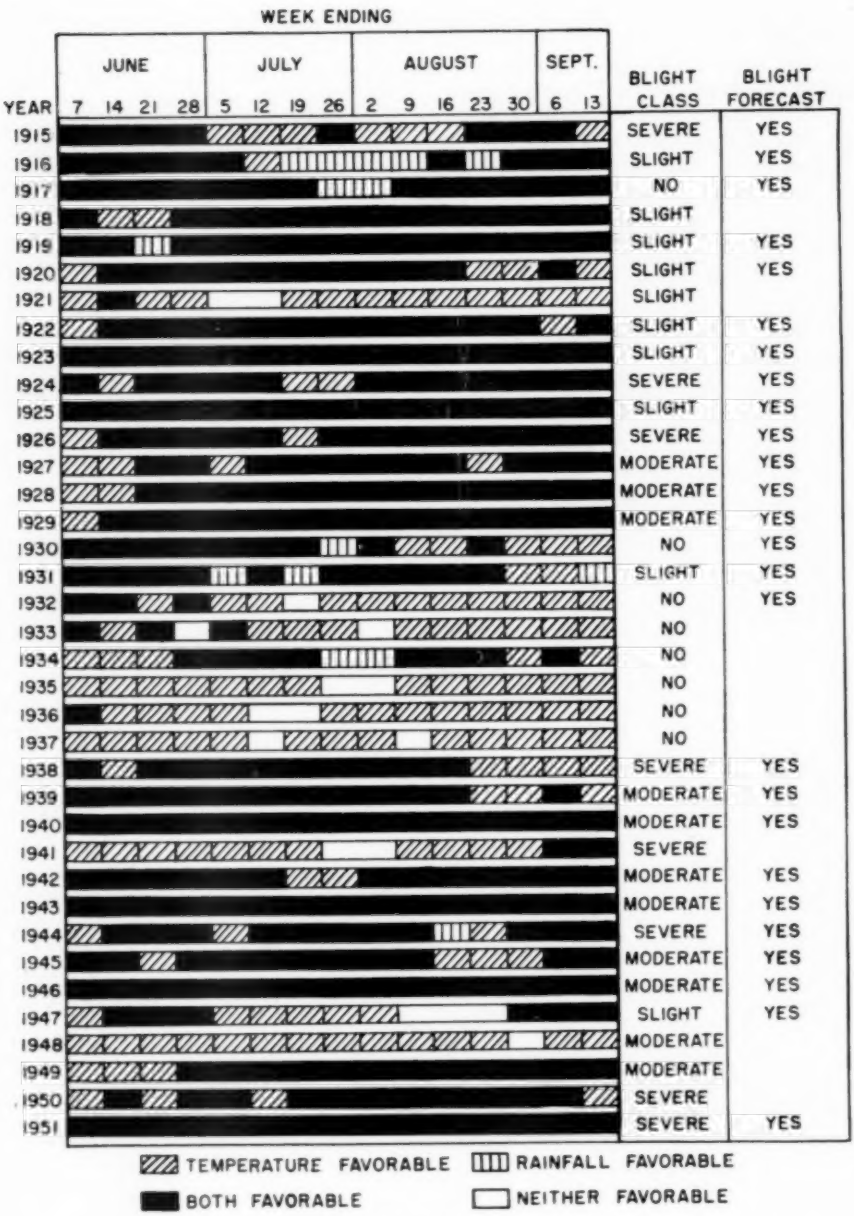


FIGURE 2.—The severity and forecast of blight in relation to the weekly mean temperature and cumulative amount of rainfall in Wisconsin for a 37 year period. Positive blight forecast if temperature and rainfall favorable for two consecutive weeks in June.

tively, for the three years for which blight was forecast and did not occur. Although the percentage accuracy of positive blight forecasts was high when the "critical period" was extended to include two months there would be little confidence in the method as a result of the occurrence of a severe and a moderate blight outbreak which were not forecast.

Only 50 per cent of the negative forecasts based upon two consecutive favorable weeks in June and July were correct. Control measures would have been recommended in four of the eight years that blight did not occur. This might tend to undermine confidence in the method.

The Relation of Rainfall to Periods of Relative Humidity Favoring Blight Development

The explanation for the unreliability of rainfall as the sole humidity factor indicating blight development might be found in the relationship of rainfall to the occurrence of periods of relative humidity favoring the development of *Phytophthora infestans* in the field.

Laboratory studies of the blight pathogen in 1934 (4) revealed that the infestation processes *i.e.* sporulation, spore germination and penetration can occur within 9-12 hours if concurrent temperatures and humidity are 54-64°F. and 90-100 per cent, respectively. Abundant sporulation occurred in a saturated atmosphere of 100 per cent humidity. Spore germination requires a saturated atmosphere or free water. These results coupled with the results obtained from local field studies in 1949-1950 suggested that periods of 10 hours or more of relative humidity 90 per cent or higher would allow the successful completion of the infection processes. Moreover, the blight studies in the north central region have shown that in most instances in the field, free water is present on plant parts when the relative humidity is 90 per cent or more.[1] Because a blight forecast method based solely upon rainfall as the moisture indicator of blight development seemed likely to exclude periods of favorable relative humidity, a study of the relationship of rainfall to periods of relative humidity 90 per cent or more was conducted with data obtained at Antigo, Wisconsin, in 1951 and 1952. Cumulative rainfall for a 57-day period was 9.8 inches in 1951 and 5.97 inches in 1952 for the same period. Figures 3 and 4 illustrate the relation of the daily rainfall to the number of hours per day of relative humidity 90 per cent or more for both years. Both years were blight years in the Antigo area.

In 1951, there were 36 rainless days during a 64-day period that records were taken. On 23 of these days, 64 per cent, there were periods of ten hours or more of relative humidity 90 per cent or more. Incidentally, during all of these periods, the temperature was below 75°F. These periods, then, would be favorable for sporulation, germination and penetration of the blight pathogen. With the exception of six days, the relative humidity was 90 per cent or greater for ten hours or more during the days that measurable rain fell.

[1] At Bedford, Indiana, in 1949, dew was observed on potato and tomato foliage on 24 nights. The relative humidity on each of these nights was 90 per cent or more. In the same year at Clear Lake, Iowa, the relative humidity was 90 per cent or more on each of the 43 nights that dew occurred. At Ames, Iowa, in 1952, the relative humidity was 90 per cent or more during 48 of the 54 nights that dew occurred.

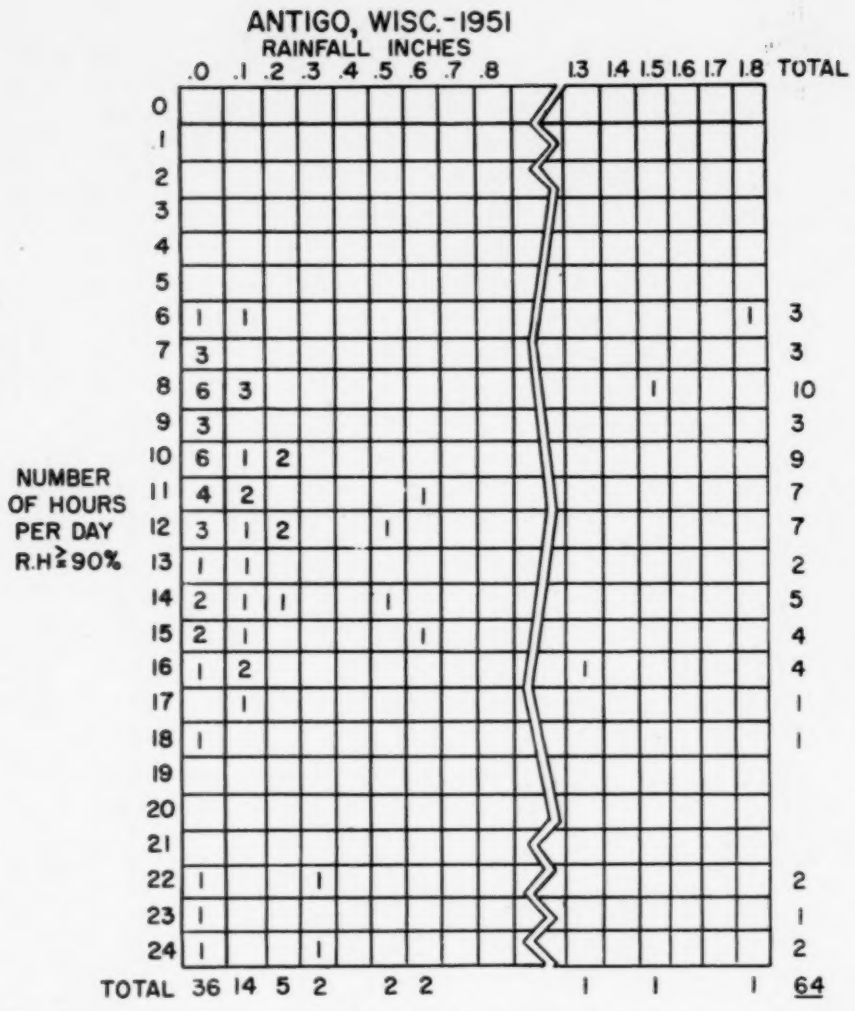


FIGURE 3.—The relation of rainfall to the number of hours per day of relative humidity = 90 per cent for a period of 64 days at Antigo, Wisconsin — 1951.

In 1952, there were 70 rainless days during a 96-day period that records were kept in the Antigo potato plot. Of these days, 54 had a period of 10 or more hours of 90 per cent or more relative humidity. On 22 of the 26 days that rainfall was measurable, there were periods of 10 or more hours of relative humidity 90 per cent or more.

Therefore, during rainy or rainless periods, the hygrograph records the humidity periods essential for the infection processes of the blight pathogen. Apparently, there were some days when rainfall was as much as 1.5 inches and 1.8 inches and there were but 8 and 6 hours, respectively,

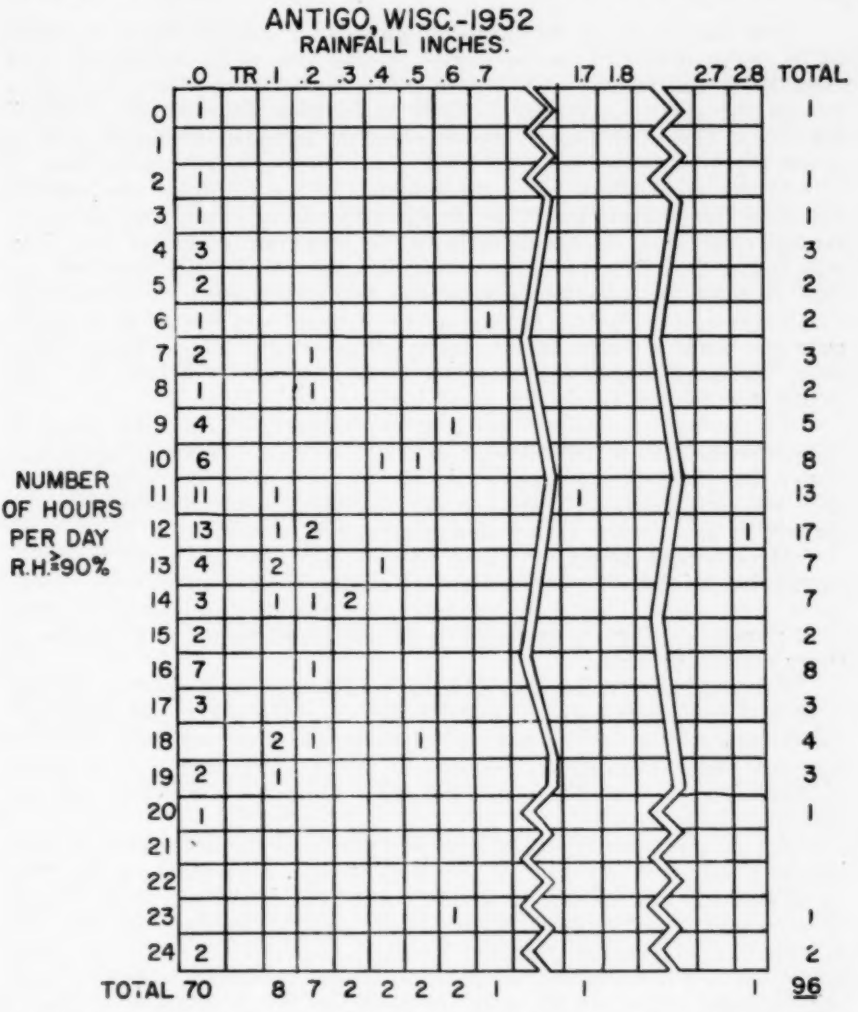


FIGURE 4.—The relation of rainfall to the number of hours per day of relative humidity = 90 per cent for a period of 96 days at Antigo, Wisconsin — 1952.

of relative humidity 90 per cent or more. Obviously, rainfall manifests only part of the true moisture situation that influences blight development.

DISCUSSION

The above results indicated that the cumulative rainfall method of forecasting potato blight in Wisconsin was unreliable. For the most part, under the temperature-rainfall limitations imposed by the method the temperatures were favorable for blight, but the so-called "critical" cumulative rainfall line was insufficiently critical in differentiating blight from no-blight years.

The inadequacy of the "critical" cumulative rainfall line is revealed by its comparison with the cumulative rainfall lines of the individual years since 1915. The rainfall lines of two of the severe-, two of the moderate-, two of the slight- and five no-blight years were beneath the "critical" line. Most inconsistent were the slopes of the cumulative rainfall lines of seven slight-blight years which were above the "critical" rainfall line.

In the slight-blight years, the presence of the pathogen was known; hence, its development should be dependent upon the ensuing temperature-rainfall conditions. If periods of favorable temperature-rainfall were few, only a slight amount of blight would be anticipated. Such was not the case. In 1918, favorable temperature and rainfall prevailed for 12 consecutive weeks and yet only a slight amount of blight was found. In contrast, only one week of favorable conditions obtained in 1921,—a slight blight year. The same inconsistencies in the number of weeks of favorable conditions are evident within the other blight classes.

The season of 1941 is also a salient example of the inadequacy of cumulative rainfall as an indicator of blight severity. Although blight was severe that year, the cumulative rainfall remained below the "critical" line until the 14th week. In 1948, a moderate blight amount developed in the absence of any periods of favorable cumulative rainfall.

Hypothetical blight forecasts based upon an uncritical "critical" cumulative rainfall line might seem ridiculous. Nonetheless, such "hindcasts" were made. They were interesting but would be of little consolation to a grower relying on the validity of such predictions in developing a spray control program.

For example, during 1915 blight would have been forecast during June and not again until August 30. But actually blight had developed rather extensively by August 11 when it was first reported. Thus a renewed blight warning on August 30 would have been a little tardy. Furthermore, the rainfall from June 28 to August 11 was favorable for only one of six weeks.

Late blight severity in the field depends upon the occurrence of high humidity and free moisture on the host foliage. *Phytophthora infestans* sporulates (4) and spreads in the field when humidities are above 90 per cent (5,8,13). Furthermore, spores of the fungus require free water to germinate and penetrate the host plant (1,2,6,7,10,11,12). Consequently, the spread and development of the blight fungus is enhanced only by those rainy periods which supply moisture conditions for a sufficient length of time to allow sporulation and germination. However, other phenomena such as dew deposition, ground fog and guttation provide blight-favorable moisture conditions. With few exceptions dew depositions and ground fog are indicated by relative humidities of 90 per cent or more.

These periods of favorable humidity conditions can be recorded by a hygrograph. This was demonstrated by the occurrence of ten hours or more of relative humidity 90 per cent or more during many rainless days at Antigo, Wisconsin. Furthermore, the results obtained at Antigo indicated that periods of relative humidity favorable for blight occurred during most of the rainy periods. Therefore the hygrograph seems to provide a more complete record of humidity conditions favoring late blight than does rainfall data alone because the hygrograph records the humidities associated with rainfall, dew deposition, fog and saturated atmosphere.

Summary

For the past 37 years in Wisconsin, there have been 8 severe, 11 moderate, 10 slight years and 8 no-blight years.

Weekly mean temperatures and cumulative rainfall were tabulated for a period of 15 weeks, June 1 to September 13 for each of the 37 years. During July, the weekly mean temperatures for the no-blight years were somewhat higher than for the other categories but were beneath the critical 75°F. during the total 15-week period.

Slopes were computed for the 15-week period cumulative rainfall for each year. Differences between the slopes of the four blight severity groups were not significant.

The weekly cumulative rainfall of the severe blight years at the end of the fifteen week period was 4.4 inches greater than for the no-blight years. The final cumulative values for the severe, moderate and slight blight groups were within 1.8 inches of each other.

A critical rainfall line of 0.8 inches was established midway between the mean slopes of the severe and no-blight years.

The weekly mean temperatures and cumulative rainfall of the individual years were compared with the designated "critical" temperature and rainfall lines. Temperatures equal to or below, and cumulative rainfall equal to or above the critical lines were considered favorable to late blight development.

Hypothetical late blight forecasts based upon the occurrence of favorable conditions for two consecutive weeks in June, July and June and July since 1915 were shown. In these forecasts the severe and slight blight years were indistinguishable. Furthermore, these two consecutive favorable weeks during the above periods failed to differentiate blight and no-blight years.

The independence of favorable periods of high humidity from the amount of rainfall was illustrated and offered as evidence for the inadequacy of cumulative rainfall in differentiating the blight severity of various years.

During a 57-day period in a late blight plot at Antigo, Wisconsin, in 1951 there were 9.8 inches of cumulative rainfall in conjunction with 45 periods of ten hours or more of relative humidity 90 per cent or more. For the same 57-day period in 1952, there were 5.97 inches of cumulative rainfall in conjunction with 54 periods of ten hours or more of relative humidity 90 per cent or more. Apparently, the number of ten-hour or more periods of relative humidity 90 per cent or more, is not dependent upon the amount of cumulative rainfall.

Literature Cited

1. Beaumont, A. 1931. The relation of weather to the appearance and progress of potato late blight. Report Agr. Meterol, Conf.
2. ———— 1947. The dependence on the weather of dates of outbreak of potato blight epidemics. Trans. Brit. Myc. Soc. 31: parts 1-2: 45-53.
3. Cook, H. T. 1949. Forecasting late blight epiphytotics of potato and tomatoes. Jour. Agr. Res. 78: 545-563.
4. Crosier, W. 1934. Studies in the biology of *Phytophthora infestans* (Mont.) DeBary N. Y. (Cornell) Agr. Exp. Sta. Mem. 155: 1-40.
5. ———— and D. Reddick. 1935 Some ecologic relations of the potato and its chief fungus parasite, *Phytophthora infestans*. Amer. Potato Jour. 12: 205-219.

6. Duírenoy, J. 1932. Les conditiones meteoroliques que permittent l'infection des pommes de terre par le *Phytophthora infestans.* Assoc. Franc pour L'avancement des Science 5th Session: 250-251.
7. Everdingen, E. van 1926. Het verband tusschen de weersgesteldheid en de aardappelziekte *Phytophthora infestans.* Tijdschr. Plantenziekten 32: 129-140.
8. Harrison, A. L. 1947. The relation of weather to epiphytotics of late blight on tomatoes. Phytopath. 37: 533-538.
9. Hyre, R. and J. G. Horsfall 1951. Forcasting potato late blight in Connecticut. Pl. Dis. Reporter. 35: 423-431.
10. Jones, L. R., N. J. Giddings and B. F. Lutman. 1912. Investigations of the potato fungus *Phytophthora infestans.* Vt. Agr. Exp. Sta. Bull. 168.
11. Melhus, I. E. 1915 Germination and infection with the fungus of the late blight of potato. *Phytophthora infestans.* Univ. Wis. Agr. Exp. Sta. Res. Bull. 37: 1-64.
12. Reddick, D. 1928. Potato blight. Amer. Potato Jour. 5: 285-288.
13. Segura, B. de 1950. Posibilidad de pronosticar la iniciacion y progreso del "hielo" de la papa *Phytophthora infestans.* Centro Nac. de Invest. y Exp. Agricola de "La Molina" Bol. 39: 1-12.
14. Wallin, J. R. and R. W. Samson 1952 Forecasting late blight in Indiana from mean temperature and cumulative rainfall data. Phytopath. 42: 482.
15. ———— and P. E. Waggoner 1949. The influence of weekly cumulative rainfall and temperature on potato late blight epiphytotics in Iowa. Pl. Dis. Reporter. 33: 210-218.

THE EFFECT OF DEPTH OF PLANTING ON GERMINATION, LEVEL OF TUBER FORMATION AND YIELD OF THE POTATO CROP[1]

M. A. Moursi[2]

Introduction

The depth of planting of potatoes varies with soil type and the method of planting. However, planting is usually shallower when hand method is used than when the machine planters are available.

Hardenburg (2) stated that shallow planting hastens the emergence of plants whereas Moore (3), believes that shallow planting takes more time to emerge. Zavitz (5) found that when seeds were planted near the surface of the soil, the tubers were formed at a bit deeper than the mother tubers. He also showed that when the mother tubers were deeply planted, the tubers were formed near the surface. Hardenburg (2) found also that yields were about the same for the 2 and 4-inch planting depths. In this study, the effect of depth of planting on germination, level of tuber formation and yield of the potato crop is investigated.

[1] Accepted for publication June 5, 1953.
[2] Vegetable Department, Alexandria University, Alexandria, Egypt.

Materials and Methods

This experiment was conducted at Dryden Mains Edinburgh University Agricultural Experimental Farm. Long. : 30° 12′ W. Lat. : 55° 52′ N Alt. : 639 feet above sea level. In this farm, the soil was chocolate in appearance and its surface was predominantly gravelly, with loam with a penetrable yellowish subsoil. The soil pH was 6.2 at the time of planting. Kerr's Pink variety was planted on May 12th, 1951. The combination of depth of planting with some other cultural treatments was arranged in factorial experiment in randomized block system.

The two depths of planting adopted in this investigation were shallow planting where the potatoes were planted 2 inches deep and deep planting where the potatoes were planted 5 inches deep.

When the sprouts broke the ground and started to unfold their first leaves, they were counted. The number of plants per plot was recorded at two-day intervals during the germination period. The germination rate index* (1) was worked out for each plot. The depth of tuber formation from the soil surface was estimated.

Results and Discussion

Rate of Plant Emergence.

The analysis of variance of germination rate index indicates that there is a highly significant difference caused by depth of planting (Table 1).

Table 1.—*The analysis of variance of the germination rate index.*

Due to	d.f.	M. S. S.
Total	39	
Block	3	2859.7
Depth of planting	1	147622.5 xx
Error	35	2981.77

xx Significant at 1 per cent level.

The results are presented graphically in figure 1. It will be seen that the speed of emergence of shallow-planted tubers was more rapid than the deep-planted tubers until the 24th of June. Then the deep-planted tubers caught up and when plant emergence was complete, there was no difference in favor of any treatment. This shows that depth of planting has no effect on the establishment of plants in this study. Similar results were also obtained by Hardenburg (2) whereas Moore (3) came to different conclusions because of the different conditions under which Moore carried out his experiment.

Depth of Level of Tuber Formation.

The cumulative percentage frequencies of level of tuber formation are shown in figure 2 and table 2. It is apparent that tubers are formed

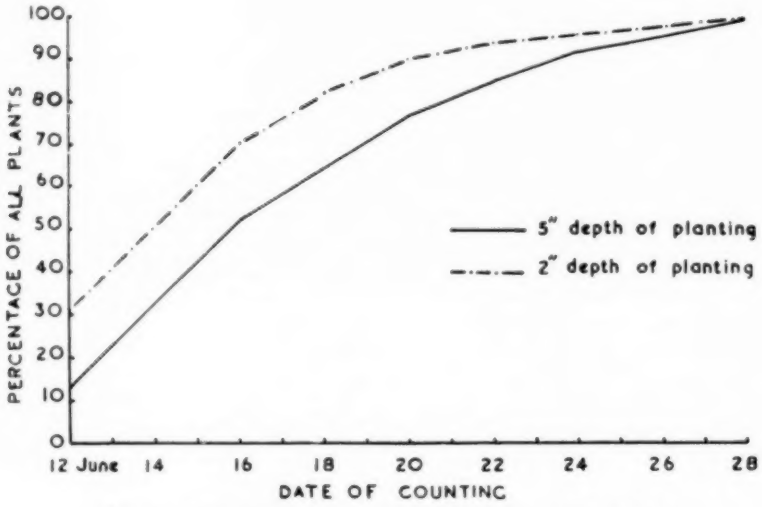


Fig. I Percentage of plants which have germinated by stated dates.

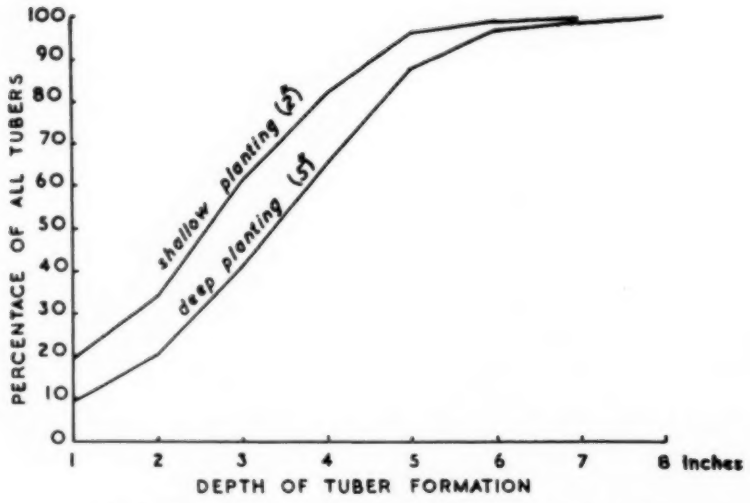


Fig. II Percentage of depth of tubers which have formed by stated depth from soil surface.

at 2, 6, and 3 and 4-inch depths for potatoes planted at 2 and 5-inch depths, respectively. Here the depth of tuber formation was estimated as the depth where one-half the number of tubers was formed. That is to say, we take the median of the frequency distribution of level of tuber formation.

TABLE 2.—*Mean and median of depth of tuber formation.*

	Median Inch	S.E.	Mean Inch	S.E.
Shallow planting	2.6	0.021	2.556	0.017
Deep planting	3.4	0.075	3.25	0.06

The above results show that when mother tubers were planted at 2 inches, the tubers were formed at 2.6 inches; whereas, when planted at a depth of 5 inches, the tubers were formed at 3.4 inch.

Results of similar magnitude were also obtained by Zavitz (5).

It is suggested that under our farm conditions mother tubers could be planted at a depth of approximately 6 inches as the depth of the tuber is decreased by the chain harrow treatment.

Study of the Distribution of Depth of Tubers

B_2 and B_1 (4) which are measures of the kurtosis and skewness of the distribution have been obtained.

These are shown in Table 3.

TABLE 3.

Shallow Planting	B_2	4.99	S.E.	0.580
	$\sqrt{B_1}$	0.21	S.E.	0.091
Deep Planting	B_2	2.23	S.E.	0.19
	$\sqrt{B_1}$	0.13	S.E.	0.095

(Standard errors calculated on the basis of normality).

The distributions therefore are:

a. leptokurtic for shallow planting and platykurtic for deep planting *b.* the distribution of the shallow planting is significantly skew. The mean depth of tuber formation is about 0.04 inch less than the median.

Response of the Yield to the Depth of Planting.

The shallow-planted tubers yielded more than the deep-planted ones by 2.34 per cent. The difference in favor of the shallow planting did not reach the significant level. This conclusion is in agreement with the results of the 2- and the 4-inch planting depths obtained by Hardenburg (2) who found that yields were reduced by planting at 6 inches in both 1929 and 1930 when rain fall was normal; they increased in 1931 when the season was exceptionally dry.

The treatment should be conducted over a period of several seasons and at widely different depths, before any conclusion may be drawn.

Summary

The effect of depth of planting was studied and it was found that:

1) Shallow planting hastened the speed of emergence of plants.
2) Depth of planting under investigation had no effect on the establishment of plants.
3) Tubers tended to develop within the range of 2.3 to 3.5 inch depth, and
4) Similar yields were obtained for the 2 and 5-inch depth of planting.

Literature Cited

1. Bartlett, M. S. 1937. Supp. Jour. Roy. Statist. Soc. Vol. 4. (164)
2. Hardenburg, E. V. 1935. Greensprouting seed potatoes. Cornell Univ. Agr. Exp. Sta. Bull. (P. 632)
3. Moore, G. C. 1937. Soil and plant response to certain methods of potato cultivation. Cornell Univ. Agr. Exp. Sta. Bull. (P. 662)
4. Tippett, L. H. C. 1941. The methods of statistics. London Williams and Norgate, Ltd. (P. 33). Great Russell St.
5. Zavitz, C. A. 1916. Potatoes. Ontario Dept. Agr. Bull. (P. 239)

THE REDUCTION OF INJURIES TO POTATO TUBERS THROUGH THE USE OF PADDING MATERIALS[1]

R. B. HOPKINS[2]

INTRODUCTION

In the New England States, and in Maine in particular, the barrel is used as a container in which to handle potatoes. Hawkins (1) recommends the use of a rubber pad in the bottom of the barrel to reduce the number of injuries which occur from the tubers striking the bottom Humphrey (2) of Idaho recommends that hoppers of handling equipment, sacking platforms and the bottoms of truck beds used for hauling potatoes in sacks be padded with sponge rubber to reduce injuries.

During the past few years sponge rubber pads have been used to some extent in Maine. However, the barrels are usually handled rather roughly, and the farmers have found it difficult to fasten the pads permanently in place. Prior to 1951, when rubber became difficult to obtain, some barrels were lined with a sponge-like rubber which was fused to the barrel interior. Since these barrels were expensive, their chief use was found in handling the potatoes within the storage at shipping time. Another practice was to fuse the rubber to new barrel bottoms before they were coopered into barrels.

The purpose of a padding material is to absorb the mechanical energy caused by the motion of the object to be protected. A tuber at a distance above a surface contains potential energy which must be dissipated if the tuber is dropped on that surface. If the surface is highly resilient it will compress under the impact of the tuber and absorb much of the energy. If the surface is not resilient the energy will not be absorbed by the surface and the tuber may be injured by the impact. The ideal padding or energy-absorbing material is capable of a relatively large deflection in proportion to its thickness and yet return to its original thickness when the load is removed.

The injuries which result from tubers striking a non-resilient object are of two types. One type is the familiar shatter injury which is visible externally. The other type occurs within the tuber and is sometimes referred to as "black spot" or "internal black spot." According to Wiant (5) black spot is caused by a mechanical injury. The affected tissues turn black within twenty-four hours. In some cases there is no external evidence of the injury whereas in others a sunken area over the injury may develop due to drying out of the tissues. Scudder, Jacob, and Thompson, (4) reported that the tissues shrink and turn slate-gray upon drying. These investigators reported differences in susceptibility among varieties, and also a positive correlation between black spot and specific gravity of the tubers. There is some evidence that the tubers are predisposed to black spot before

[1]Accepted for publication June 16, 1953.

[2]Formerly Assistant Agricultural Engineer, Maine Agricultural Experiment Station, Orono, Maine.

The author wishes to acknowledge the cooperation of Kimberly-Clark Corporation and International Balsa Corporation in providing materials used in the experimental program.

Appreciation for their cooperation is extended to the growers on whose farms experiments were conducted.

harvest, possibly because of a nutritional deficiency. Wiant (5) and Wiant, Findlen and Kaufman (6) reported that this type of injury occurs more frequently at lower temperatures.

Field Tests of Barrel Pads

The expense of sponge rubber and the possibility that it might become unobtainable led to a study of alternate materials. This work was begun in the autumn of 1950 with a field test of the following materials: (a) one-quarter inch thick sponge rubber, (b) one-eighth inch thick sheet rubber, (c) a corrugated paper approximately three-thirty seconds inch thick, (d) a commercially available creped wadding one-quarter inch thick and (e) 100-pound burlap potato sack, doubled with the corners folded under to approximate a round pad.

The five materials were tested in comparison with unpadded barrels through latin square experiments on three different farms where commercial harvest operations were in progress. Each of six pickers filled a barrel containing each treatment. A sample of approximately one-third of the barrel's contents was examined by a Federal-State Inspector. He separated each sample into the following groups:

1. Culls — all tubers under one and one-half inches in diameter and all larger tubers which would be disqualified from U. S. No. 1 grade because of defects other than mechanical injuries. Some examples of such defects are sunburn, growth cracks, and rot.

2. Major injury — tubers which were disqualified from U. S. No. 1 grade because of mechanical injuries.

3. Minor injury — tubers with mechanical injuries which penetrated the flesh but were not sufficiently serious to disqualify the tubers from U. S. No. 1 grade.

4. Uninjured — tubers without mechanical injuries.

The percentages by weight of tubers bearing major and minor injuries in each sample were computed. Separate analyses of variance of major and minor injuries in each of the three experiments revealed significant differences in major injuries in one experiment. In that experiment there were significantly more major injuries in the barrels without pads than in the barrels with each type of pad.

During the 1951 harvest season three more latin square experiments were conducted on two farms in Aroostook County, Maine. The materials tested were (a) one-quarter inch thick sponge rubber, (b) one-half inch thick creped wadding with a covering of kraft paper, (c) a 100 pound burlap potato sack, and (d) a one-half inch thickness of balsa wood. In each experiment all of the potatoes were picked up by the same individual. Instead of filling the barrels, the contents of only one picking basket were emptied into each barrel. This resulted in samples of approximately 40 pounds each.

The tubers were examined and classified in the same manner as in the previous year. In one experiment major injuries from barrels without any pad were again significantly greater than the major injuries from barrels with each type of pad. During each season the experiments were conducted with tubers of the Katahdin variety, the one most commonly grown in Aroostook County at the present time.

Laboratory Tests of Padding Materials on Stored Potatoes

Dirt-free Surfaces

Laboratory tests were conducted in addition to the field tests which have been described. In December, 1950 and January, 1951, tubers of the Katahdin variety were selected from the storage bins of Aroostook Farm at Presque Isle, Maine. Five groups of tubers without external injuries were selected according to weight. These groups were 1¾, 2½, 4½, 7¾, and 10¾ ounces which correspond roughly to 1¾, 2, 2½, 3, 3½-inch tubers respectively. Approximately 25 tubers of each group were dropped individually from the top to the bottom of the barrel, a distance of about 28 inches. The bottom of the barrel or the barrel pad being tested was wetted with a solution of black clothing dye. When each tuber was removed from the barrel, the spot where it had struck the bottom was circled with a black crayon.

After a period of a week or more the tubers were examined for both external and internal injuries. Where the external injuries were severe, they consisted of cracks or shatter injuries. Some of the less severe injuries were indentations which may have resulted from the presence of granular soil particles. Tubers which did not have external injuries were examined for internal injuries (black spot) by removing slices of the flesh from the area which had struck the barrel bottom or pad. Some examples of internal injuries are shown in figure 1.

In the first group of tests, tubers at temperatures of 43°, 53°, and 56° F were dropped into the barrel without a pad. Tubers at temperatures of 43° F were dropped on one-quarter inch thick sponge rubber, one-eighth inch thick sheet rubber, corrugated paper, a 100-pound burlap potato sack and one-quarter inch thick creped wadding. In addition, tubers were also dropped into a barrel which had the interior coated with a sponge-like rubber. The coating on the bottom was approximately five-eighths inch thick.

The test of the creped wadding was unsatisfactory because the wet material disintegrated from being struck by the tubers. However, information was obtained from the test which indicated that the one-quarter inch thickness was insufficient and the test was repeated using one-half inch thickness of the material. The test without a pad was also repeated to provide a check with the previous tests. Table 1 presents the results of the first test and the later test of one-half inch thickness of creped wadding. These data indicate that each padding material reduced the percentage of injured tubers. However, the corrugated paper was shown to be inferior to the other materials. A tendency was also indicated for the percentage of injured tubers to increase as the weight of individual tubers became greater.

Dirt-covered Surfaces

Materials which potatoes contact frequently became covered with dirt, especially during a wet harvest season. Further tests were conducted with some of the same materials as tested previously. Dirt which was obtained from a commercial potato washer was mixed with water, and equal amounts were spread on the barrel bottom and on the sheet rubber, sponge rubber, burlap sack, and one-half inch thickness of creped

FIGURE 1.—Typical internal injury resulting from dropping tests.

TABLE 1.—*Results of dropping tubers on various materials covering a barrel bottom.*

Weight Oz.	Percentage of Injured Tubers[1]						
	No Pad	Sheet Rubber ⅛ in. Thick	Sponge Rubber ¼ in. Thick	Corrugated Paper	Burlap Sack	Rubber lined Barrel	Creped Wadding ½ in. Thick
1¾	24	0	0	0	0	0	0
2½	32	4	0	8	0	0	0
4½	24	0	0	16	0	0	0
7¾	44	0	0	48	4	0	4
10¾	53	7	0	27	7	13	29

[1]Height of drop was approximately 28 inches; tuber temperature 42° to 43° F.

wadding. Although it was difficult to spread the dirt evenly, the covering was approximately one-eighth inch thick. After the dirt was thoroughly dry, tubers were dropped on each of the materials as before, with the exception that powdered blue chalk was placed on the dirt as a means of indicating where the tubers struck. A dye solution would have softened the dirt and partially nullified the effect of placing the dirt on the surface. Tubers were also dropped on the unpadded barrel bottom to provide a basis for comparison with previous tests. The temperature of the tubers was 44° F. The tubers were selected over a greater range of weights with two-ounce increments between groups. Because the dirt crumbled from being struck by the tubers, in each case the lightest tubers were dropped first, followed by the heavier groups in succession.

Regression lines which represent the results of this test are presented in figure 2. Each of the dirt-covered pads reduced the percentage of injured tubers considerably over the omission of a pad. Removal of the dirt from the unpadded barrel bottom decreased the percentage of injured tubers. The results indicate that the use of a dirt-covered pad is preferable to the omission of a pad whether the unpadded barrel is clean or dirt-covered. The high incidence of external injuries when the tubers were dropped on the dirt-covered barrel bottom was partially caused by the presence of small, granular soil particles which were pressed into the flesh. The decrease of internal injuries with heavier tubers was probably due to the crumbling of the dirt from the impact of the tubers since the lightest tubers were dropped first. In figure 2 only the regression on tuber weight of all injuries with the clean, unpadded barrel is statistically significant.

EFFECT OF TUBER TEMPERATURE ON INJURIES

The effect of tuber temperature on the occurrence of injuries is presented in the form of regression lines in figure 3. These lines were computed from the data obtained from dropping tubers on a dirt-free barrel bottom in the previously described tests. The data at temperatures of 42°, 43°, and 44° F were combined in a single line whereas the data at temperatures of 53° and 56° F were combined in another line. The regression of internal injuries on tuber weight at the temperatures of

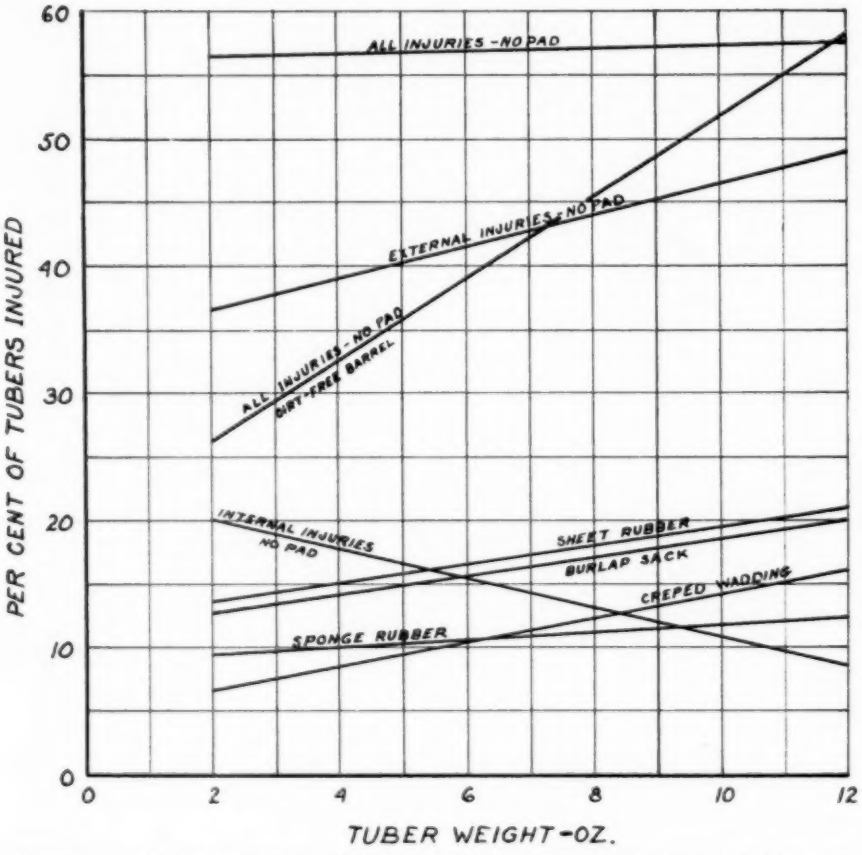


FIGURE 2.—Effect of dropping tubers on dirt covered surfaces. Regression lines for sheet rubber, burlap sacks, sponge rubber and creped wadding represent all injuries.

42° to 44° F is not statistically significant while all the other regressions are highly significant. The lines indicate a definite decrease of external injuries accompanying the change in temperatures from the range of 42° to 44° F to the range of 53° to 56° F for all sizes of tubers. All injuries increased with greater tuber weight. However, because the effect of temperature on internal injuries is not clearly indicated the effect of temperature on all injuries is also somewhat obscure. The results indicate a tendency for all injuries to be reduced at the higher temperature range with tubers under 12 ounces in weight. Furthermore, the lines indicate that tuber size influences the frequency with which both external and internal injuries occur.

LABORATORY TESTS AT TIME OF HARVEST

Because a new material, one-half inch thick balsa wood, was introduced in the field trials in 1951 a laboratory test was also made with the balsa wood. Tests of an unpadded barrel bottom and one-quarter inch thick

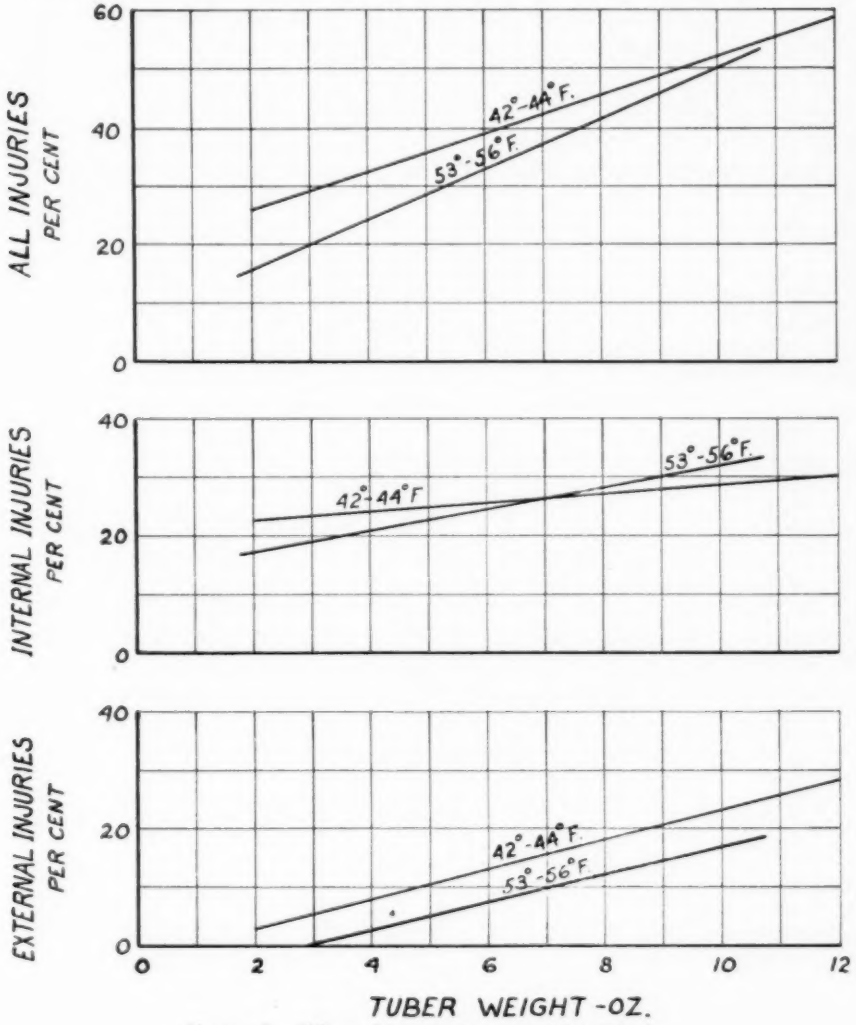


FIGURE 3.—Effect of temperatures on tuber injuries.

sponge rubber were made for comparison. The tubers used in these tests were of the Katahdin variety at a temperature of 48° F. The results of the tests are presented in figure 4 in the form of regression lines. The regressions of external injuries and the sum of external and internal injuries on tuber weight without a pad are highly significant. The other regressions are not statistically significant. Apparently, the balsa wood pad is not quite as effective in preventing injuries as the sponge rubber pad, but is much more effective than the (bare) barrel bottom. There were very few internal injuries in the tubers dropped on the balsa and sponge pads, nearly all were external in nature.

The test results presented in figure 4 are at variance with some of

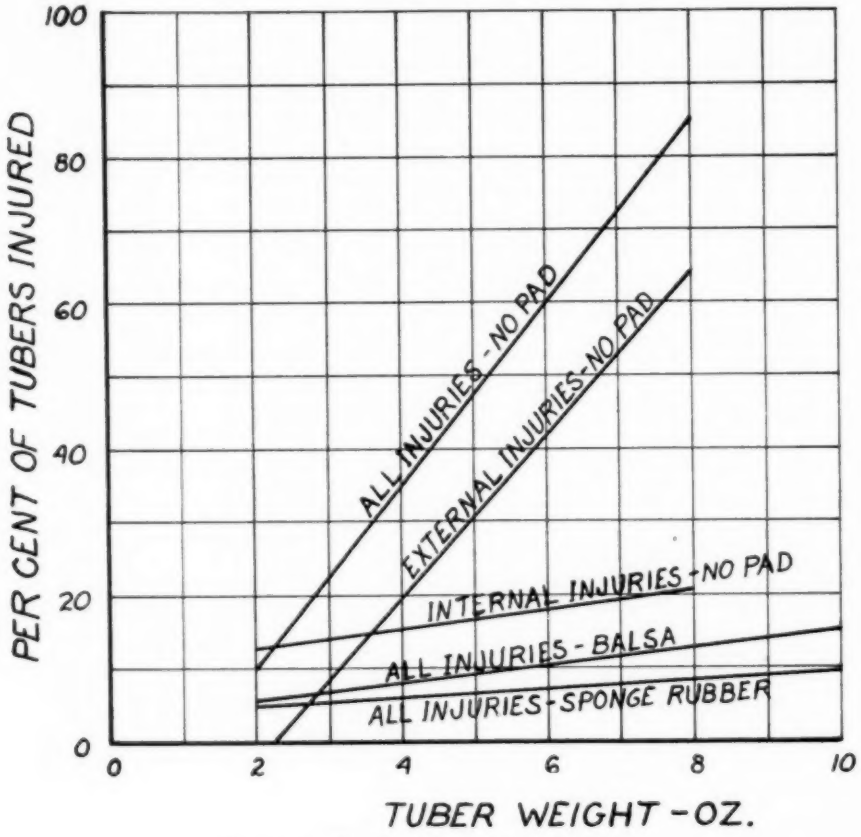


FIGURE 4.—Results of test at time of harvest.

the results presented in table 1 and figure 3. The tubers in this test had been dug less than one month previously while in the earlier tests the tubers had been dug for a period of three months or more. It is probable that the tubers in the last test were more turgid because they had a shorter period of time to release moisture. Werner (4) states that the storage of tubers in a cool place will increase the turgidity, thus making the tubers more likely to crack upon receiving a shock.

EFFECT OF MECHANICAL ENERGY CONTENTS ON INJURIES

The mechanical energy content of a tuber with respect to an object at a lower level is composed of two factors, tuber weight and the distance which the tubers must fall to strike the object. The mechanical energy content increases linearly with a linear increase in either tuber weight or vertical distance between the two objects. Therefore, the linear increase of injuries with increase in tuber weights in figures 3 and 4 indicates that the mechanical energy contained by a tuber at the moment of impact

is the primary external factor which determines the frequency with which injuries occur under a particular set of conditions.

Summary

Field and laboratory tests were conducted to measure the effectiveness of several materials as barrel pads.

The use of some type of pad in the bottoms of barrels reduced the percentage of tubers which sustained major (grade) injuries.

Sponge rubber one-quarter inch thick was somewhat more effective in preventing tuber injuries than any of the other materials tested. Sheet rubber one-eighth inch thick, a 100-pound burlap potato sack, one-half inch thick creped wadding with a covering of kraft paper on the top surface, and one-half inch thick balsa wood were slightly inferior to the one-quarter inch thick sponge rubber.

The presence of a one-eighth inch thick layer of dirt on a pad or surface which was struck by falling tubers caused considerably more injuries than when the pad or surface was free of dirt. Dirt-covered pads caused fewer injuries than a dirt-free barrel bottom with tubers of the same weight and temperature.

Tubers of the same weight sustained approximately six per cent more external injuries at temperatures in the range of 42° to 44° F than at temperatures in the range of 53° to 56° F. The relationship of tuber temperature to internal injuries was not determined.

The percentage of tubers which sustained either external or internal injuries increased with individual tuber weight. It may be concluded that when tubers at the same temperature strike the same object the mechanical energy content of the tubers is the external factor which determines whether the tubers will sustain either external or internal injuries.

Literature Cited

1. Hawkins, A. Harvest and store more marketable potatoes. Agricultural Extension Service, Univ. of Conn. (Unnumbered mimeographed publication).
2. Humphrey ,E. 1950. Steps that can be tak n to reduce mechanical damage to potatoes at harvest time. Idaho Agr. Exp. Sta. Bull. 278.
3. Scudder, W. T., Jacob, W. C. and Thompson, H. C. 1950. Varietal susceptibility and the effect of potash on the incidence of black spot in potatoes. Amer. Soc. Hort. Sci. Proc. 56: 343-348.
4. Werner, H. O. 1947. Commercial potato production in Nebraska. Nebr. Agr. Exp. Sta. Bull. 384.
5. Wiant, J. S., Findlen, H., and Kaufman, J. 1951. Effect of temperature on black spot in Long Island and Red River Valley potatoes. Amer. Potato Jour. 28: 753-765.
6. ———. 1945. Internal black spot of Long Island potato tubers. Amer. Potato Jour. 22: 6-11.

SPRAYING or DUSTING
USE
"OHIO SUPERSPRAY" HYDRATED LIME

with a guaranteed fineness of 99½% passing a screen having 105625 openings per square inch. It contains magnesium and calcium. Insures greatei coverage and yields.

OHIO HYDRATE & SUPPLY COMPANY
WOODVILLE, OHIO

Manufacturers of Various Forms of Lime and Limestone Products

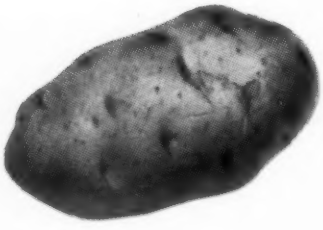
---

INCREASE YIELD AND QUALITY WITH FERTILIZER

CONTAINING SOLUBLE MAGNESIUM—THE FOURTH PLANT FOOD ELEMENT

Sul-Po-Mag®

WATER-SOLUBLE $K_2SO_4 \cdot 2MgSO_4$
DOUBLE SULFATE OF POTASH-MAGNESIA



potash division

Sul-Po-Mag supplies a properly balanced combination of sulfate of potash and sulfate of magnesium, both in soluble form. Leading fertilizer manufacturers regularly use *Sul-Po-Mag* in their quality grades to provide soluble magnesium. Look for it *in* the bag and *on* the bag.

INTERNATIONAL MINERALS & CHEMICAL CORPORATION
General Offices: 20 North Wacker Drive, Chicago 6

POTASH and POTATOES

In checking your yields, did a big percentage of No. 1, high-quality potatoes indicate that your crop was able to get enough potash? If not, consult your official agricultural adviser or experiment station about the fertility of your soil. Potatoes are greedy feeders on potash. For a good yield of No. 1's, soil and fertilizer should supply at least 200 lbs. of available potash (K_2O) per acre. Write us for free information.

American Potash Institute, Inc.

1102 Sixteenth St., N.W. Washington 6, D.C.

Member Companies:

American Potash & Chemical Corporation • Duval Sulphur & Potash Company • Potash Company of America • Southwest Potash Corporation • United States Potash Company

Boggs

THE "STANDARD"

Potato and Onion Grader

Not only "STANDARD" but "SUPERIOR" in Economy, Accuracy, Speed, and Adaptability.

More Boggs Graders in use than all other makes combined—there must be a reason. Send for our new circular and price list.

BOGGS MFG. CORP., Atlanta, N. Y.

University Microfilms
313 North 1st St
Ann Arbor Michigan

IRON AGE BAND WAY

Potato Planters for easier planting, greater yields!

For greater accuracy and flexibility, easier planting, greater yields—no matter what your acreage or soil condition—insist on Iron Age Potato Planters and the exclusive, scientific Iron Age Band-Way method of fertilizer placement! Band-Way sows fertilizer exactly the right distance from plants and seeds, where it does the most good. Stops fertilizer injury, leaching, fixation, burning . . . brings more plants to healthy, productive maturity . . . increases your profit per acre.

Check Iron Age's rugged construction . . . self-aligning roller bearings that mean lighter draft . . . larger, all-steel hoppers for longer life . . . and you'll see why Iron Age is your best buy! Available in one-, two-, or four-row models.

OLIVER IRON AGE *Finest in Farm Machinery*

For more details, **see your Oliver Iron Age dealer, or write to: THE OLIVER CORPORATION, Dept. 01, 400 W. Madison St., Chicago 6, Illinois.**

PLANT AND SPRAY . . . THE IRON AGE WAY